REMARKS

Prior to the present amendment, claims 1, 2, 4-7, 9-12, 14-17, 19, and 20 were pending in the present application. By this amendment, Applicants have amended claims 1, 2, 6, 7, 11, and 17 and have added new claims 21-24. Thus, claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 remain in the present application. Reconsideration and allowance of pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 in view of the above amendments and the following remarks are requested.

A. Rejection of Claims 1, 2, 4-7, 9-12, 14-17, 19, and 20 under 35 USC §112, second paragraph

The Examiner has rejected claims 1, 2, 4-7, 9-12, 14-17, 19, and 20 under 35 USC §112, second paragraph. In particular, the Examiner asserts that "[t]he term 'Ultra-uniform" in claims 1, 4, 6, 9, 11, 12, and 17 is a relative term which renders the claim indefinite." *See* page 2 of the Office Action dated December 19, 2008. Applicants have amended independent claims 1, 6, 11, and 17 to define an ultra-uniform silicide as "having approximately less than 3% variation in thickness." As defined in the present application, an ultra-uniform silicide means "a layer of silicide where there are no variations in thickness greater than about 3% of the overall thickness." *See* page 7, lines 27-28 of the present application. Thus, Applicants respectfully submit that the term "ultra-uniform" is clearly defined in the specification and claims to be a silicide that has no variations in thickness greater than about 3%. As such, the term "ultra-uniform" does not limit the silicide to any particular thickness.

As disclosed in the present application:

> Still further, it is preferable that the silicide be deposited under these power levels and deposition rates to an ultra-thin thickness of not more than 50 Å thickness in order to provide an ultra-uniform, ultra-thin silicide. The deposited silicide metal is then converted to a silicide by an annealing process, such as an anneal up to about 700°C depending upon the silicide metal being used. *See* page 8, lines 3-7 of the present application.

In the aforementioned quoted portion of the present application, Applicants respectfully submit that the expression "not more than 50 Å thickness" refers to the deposited thickness of the silicide metal – not the thickness of the subsequently formed silicide, since the phrase "under these power levels and deposition rates" refers to particular power levels and deposition rates of the silicide metal. *See*, e.g., page 7, lines 29-31 and page 8, lines 1-2 of the present application. Thus, as disclosed in the present application, in one embodiment of the present invention, an ultra-uniform silicide (i.e. a layer of silicide having no variations in thickness greater than about 3%) can be formed by depositing nickel in a vapor deposition process at power level below 500 watts direct current, at a deposition rate below 7.0 Angstroms per second, and at a thickness of not more than 50 Angstroms. *See*, e.g., page 7, lines 29-31 and page 8, lines 1-7 of the present application.

Thus, for all the foregoing reasons, Applicants respectfully submit that amended independent claims 1, 6, 11, and 17, and claims depending therefrom, meet the requirements of 35 USC §112, second paragraph.

B. **Rejection of Claims 1, 2, 4-7, 9-12, 14-17, 19, and 20 under 35 USC §103(a)**

The Examiner has rejected claims 1, 2, 4-7, 9-12, 14-17, 19, and 20 under 35 USC §103(a) as being unpatentable over U.S. patent number 6,858,506 to Kent Kuohua Chang (hereinafter "Chang") in view of U.S. patent application publication number 2004/0115929 A1 to Bi O. Lim (hereinafter "Lim") and in further view of U.S. patent application publication number 2005/0035460 A1 to Horng-Huei Tseng (hereinafter "Tseng"). For the reasons discussed below, Applicants respectfully submit that the present invention, as defined by amended independent claims 1, 6, 11, and 17, is patentably distinguishable over Chang, Lim, and Tseng, either singly or in any combination thereof.

The present invention, as defined by amended independent claim 1, includes forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. As disclosed in the present application, an ultra-uniform nickel silicide can form extremely robust nickel silicide, which has been found to be difficult to form. *See*, e.g., page 7, lines 22-26 of the present application. As disclosed in the present application, "ultra-uniform silicide" is defined as a layer of silicide having no variations in thickness greater than about 3% of the overall thickness. *See*, e.g., page 7, lines 26-28 of the present application.

As disclosed in the present application, in one embodiment of the invention, silicides 604, 606, and 608 (e.g. ultra-uniform nickel silicides) can be formed by

depositing nickel on exposed silicon areas by using a very low power deposition process, where "very low power" means a power level below 500 watts direct current. See, e.g., page 7, lines 29-32 and Figure 6 of the present application. As disclosed in the present application, the nickel can be deposition at an extra slow rate of metal deposition, which is defined to be below 7.0 Angstroms per second. *See*, e.g., page 8, lines 1-2 of the present application. Thus, in an embodiment of the present invention, an ultra-uniform, ultra-thin silicide can be advantageously provided by depositing a silicide metal (e.g. nickel) to a thickness of not more than 50 Angstroms at a deposition rate below 7.0 Angstroms per second and using an annealing process to convert the deposited silicide metal to the silicide. *See*, e.g., page 8, lines 3-7 of the present application.

In contrast to the present invention as defined by amended independent claim 1, Chang does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. Chang specifically discloses forming silicide film 234 atop gate structure 208a and heavily doped source/drain regions 218 to lower the sheet resistance at the source/drain area and the gate electrode. *See*, e.g., Figure 2G and related text of Chang. Chang further discloses that nickel silicide can be used for silicide film 234 to reduce the consumption of silicon in gate structure 208a and strained silicon layer 204. *See*, e.g., column 5, lines 2-4 of Chang. However, Chang fails to disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in amended independent claim 1. Furthermore, Chang fails to disclose any relationship between the uniformity of

silicide film 234 and the robustness of silicide film 234 or any reason for forming a silicide having a highly uniform thickness. In fact, Chang fails to even mention the uniformity of silicide film 234.

In contrast to the present invention as defined by amended independent claim 1, Lim does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. Lim specifically discloses forming a tungsten nitride layer 37 in contact hole 12 in insulating layer 11 overlying semiconductor substrate 10 and depositing tungsten layer 39 on tungsten nitride layer 37, where tungsten nitride layer 37 can be deposited by an atomic layer deposition (ALD) process, and where tungsten nitride layer 37 and tungsten layer 39 are preferably in-situ deposited in the same reaction chamber. See, e.g., paragraphs [0020], [0021], and [0026] and Figures 3 through 8 of Lim.

However, Lim fails to disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in amended independent claim 1. Thus, Lim fails to cure the aforementioned deficiencies of Chang.

In contrast to the present invention as defined by amended independent claim 1, Tseng does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. Tseng specifically discloses metal silicides 115 situated on gate electrode 111 and source/drain regions 113 in

semiconductor substrate 100, where metal silicides 115 can be titanium silicide, cobalt silicide, or nickel silicide and can have a thickness between about 50 Angstroms and 350 Angstroms. *See*, e.g., paragraph [0037] and Figure 2 of Tseng. However, Tseng fails to disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in amended independent claim 1. Thus, Tseng fails to cure the aforementioned deficiencies of Chang.

Furthermore, Tseng fails to disclose any relationship between the uniformity of metal silicides 115 and the robustness of metal silicides 115 or any reason to form a silicide having a highly uniform thickness. In fact, Tseng does not even mention the uniformity of metal silicides 115. Thus, Applicants respectfully submit that the combination of Chang, Lim, and Tseng suggested by the Examiner does not and cannot result in the present invention as defined by amended independent claim 1.

For all the foregoing reasons, Applicants respectfully submit that, at the time the invention defined by amended independent claim 1 was made, the invention would not have been obvious to a person of ordinary skill in the art by Chang, Lim, and Tseng. Thus, amended independent claim 1 is patentably distinguishable over Chang, Lim, and Tseng and, as such, claims 2, 4, and 5 depending from amended independent claim 1 are, *a fortiori*, also patentably distinguishable over Chang, Lim, and Tseng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

Independent claims 6, 11, and 17 have been amended to include similar limitations as amended independent claim 1. Thus, for similar reasons as discussed above, amended

independent claims 6, 11, and 17 are also patentably distinguishable over Chang, Lim, and Tseng, either singly or in any combination. As such, claims 7, 9, and 10 depending from amended independent claim 6, claims 12 and 14-16 depending from amended independent claim 11, and claims 19 and 20 depending from amended independent claim 17 are, *a fortiori*, also patentable over Chang, Lim, and Tseng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

C. Rejection of Claim 10 under 35 USC §103(a)

The Examiner has rejected claim 10 under 35 USC §103(a) as being unpatentable over Chang in view of Lim, and further in view of Tseng and *Silicon Processing for the VLSI Era*, Vol. 1, by Wolf et al. (hereinafter "Wolf"). As discussed above, amended independent claim 6 is patentably distinguishable over Chang, Lim, and Tseng. Thus, claim 10 depending from amended independent claim 6 is, *a fortiori*, also patentably distinguishable over Chang, Lim, and Tseng, or any combination of Chang, Lim, and Tseng with other cited art, such as Wolf, for at least the reasons presented above and also for additional limitations contained in the dependent claim.

D. Rejection of Claims 14 and 19 under 35 USC §103(a)

The Examiner has rejected claims 14 and 19 under 35 USC §103(a) as being unpatentable over Chang in view of Lim and Tseng, and further in view of Wolf. As discussed above, amended independent claims 11 and 17 are patentably distinguishable over Chang, Lim, and Tseng. Thus claim 14 depending from amended independent claim

11 and claim 19 depending from amended independent claim 17 are, *a fortiori*, also patentably distinguishable over Chang, Lim, and Tseng, or any combination of Chang, Lim, and Tseng with other cited art, such as Wolf, for at least the reasons presented above and also for additional limitations contained in each dependent claim.

E. Patentability of New Claims 21-24

As discussed above, amended independent claims 1 and 6 are patentably distinguishable over Chang, Lim, and Tseng. Thus new claims 21-23 depending from amended independent claim 1 and new claim 24 depending from amended independent claim 6 are, *a fortiori*, also patentably distinguishable over Chang, Lim, and Tseng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

F. Conclusion

For all the foregoing reasons pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 are patentably distinguishable over the cited art, and an early allowance of pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 is respectfully requested.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication, or credit any overpayment to Deposit Account No. 50-0731.

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Respectfully Submitted,
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